Science & Technology Education Symposium
September 22 and 23, 2000

Chemistry Section

Welcome to the chemistry section of the symposium. Our goal for these two days is to acquaint the participants with an on-going water study here on the LLNL site. This study is an application of many of the separate topics students would be expected to master in a typical high school chemistry course. However, our purpose is to take the study as a model that can be used in a classroom to tie together what might otherwise appear to be isolated information in a textbook for the student. We will begin with a tour of the pond on Friday afternoon, and explanations of why the pond was created, how sampling ties into water shed management and concerns. On Saturday, the participants will have an opportunity to see how sampling is done at the pond, and perform a few of the actual tests that are used in studying the pond. We have included a variety of “low tech” sampling techniques, “high tech” CBL probes that could be used, and the sensors and testing equipment that are used on site. This wide variety should allow each teacher to tailor classroom sampling and testing to his/her own particular needs. After testing, what happened to this information becomes the focus. Samples of data sets on several variables will be analyzed after the testing activity is completed. Actual data will be used, and suggestions for manipulating the data and interpretation of the resulting graphs in the classroom will be given. Data sets are included in the participants’ binder for classroom use. At the final activity, ties to the new California Science Standards for middle school and high school levels are enumerated. Lastly, there are resource lists, which include Web sites, books, agencies and some sample lessons to be used in developing a unit using an aquatic environment.

Friday Afternoon, Activity 1:

The Pond

(information from Allen/ Karen about the hows and whys for the pond. Include information on watershed from biologist?)

Saturday Morning, Activities 2 & 3:

At the Lab site, routine test sampling is done from a small row boat at the same location in the pond each time. Originally, samples where taken at a variety of locations around the pond. The pond is structured so that each bank has a different slope. The result of varying the slopes, is a variety of plant life as you travel around the pond. The water is circulated, and so stratification, that would otherwise occur in a natural pond, is eliminated. Sampling can also be done from the shore, which may be the only method available to your students.

Test Sampling Overview

pH:

Low Tech: pH papers, Universal indicator, and red cabbage indicator the students have made

High Tech: CBL and computer sensors and pH meters

Carbonates:

Low Tech: Wet lab qualitative analysis

High Tech: Spectrophotometer and reagents

Phosphorus / phosphates:

Low Tech: Wet lab qualitative analysis, colorimeteric test kit (Cole-Parmer), Lab-Aids No. 20 test kit

High Tech: Spectrophotometer and reagent

Chlorophyll A:

Must be sent out to a lab for analysis

Nitrates / Nitrogen:

Low Tech: Wet Lab qualitative analysis, water test strips, Lab-Aids No. 20 test kit

High Tech: Spectrophotometer and reagents, chromatography

Water Samplers can be used to retrieve samples from any depth, temperature and dissolved oxygen are done on the same depth samples, to show the correlation of this readings.

Dissolved Oxygen:

Low Tech: Titrimetric Test Kit (Cole-Parmer)

High Tech: CBL or computer probes used on water samples

Temperature:

Low Tech: thermometer

High Tech: CBL or other thermometer probes

Other possible tests- salinity, sulfates, refraction (photo sensor), turbidity (phosphates), density if using salt marsh, ocean, salt water aquarium or bay. Test kits/ strips are also available to test alumimun, alkalinity, ammonium, arsenic, chloride, cyanide, lead, nickel, potassium, hardness, zinc, turbidity, copper, sulfites, sulfates, and chromates.

Specific Tests

pH:

1. Use ph papers and compare to color scale on the tube to determine pH..
2. Use Universal indicator to test and compare to color chart to determine pH.
3. Have the students make their own indicator by shredding red cabbage and boiling in distilled water. Strain the liquid, and use enclosed color scale to determine pH.
4. Use CBL probe or pH meter to read pH value of water sample.

Carbonates: Check with Susan on this one

1. The carbonates of all metals except sodium, potassium, and ammonium are insoluble in water, so the addition of a dilute solution containing calcium nitrate would result in an insoluble calcium carbonate precipitate.

Several tests in book- just reference book?

Phosphates/phosporus

1. Use a colorimetric test kit (Cole-Parmer) Place sample in vial, add pre-mixed reagent ampoule, and read results by comparing with color scale.
2. Use the Lab-Aids No. 20 test kit.
3. Use the spectrophotometer and pre-mixed ampoules to test solution. It is possible to detect the presence and concentration of the ions from the

reading on the spectrophotometer and concentration curve.

Chorophyll A:

This test is sent out to a lab for analysis, it is not performed on site.

Nitrates/Nitrogen

1. Use the water quality test strips. (Nasco)
2. Use the Lab-Aids No. 20 test kit (Nasco)
3. Use qualitative analysis test. Place 2 drops of the water solution in a test tube and carefully add 10 drops of 18 M H_2SO_4. Mix thoroughly and cool. Carefully add 3-4 drops of 0.2 M $FeSO_4$ solution, allowing the latter tyo float on top of the sulfuric acid solution. Allow to stand for 1 or 2 minutes. A brown coloration at the junction of the two layers due to the presence of the complex nitrosyliron (II) ion, $Fe(NO)^{2=}$, proves the presence of nitrate.
4. Use the reagent ampoule and spectrophotometer. Reading presence and concentration from instrument and concentration curve.

Dissolved Oxygen

Use water sampler and obtain samples from several depths if possible.

1. Use titrimetric test kit or colorimetric test kits (Cole-Parmer) to determine concentration (ppm).
2. Use CBL sensor or ? to determine concentration (ppm).

Temperature

Use the same samples as for dissolved oxygen from water sampler.

1, Use thermometer, CBL or other temperature sensor.

We have a pond to sample from at will, but where will your data come from? There are many options from which to work. If your school does not happen to have a creek or pond on site, one option is to build a small scale pond of your own, so that samples can be taken on an ongoing basis, a nearby golf course or park is a likely creek or pond owner and potential sample source, a local farmer, wetlands, bay, river, or an aquarium in your classroom are also potential sample sources. The in-class aquarium has the advantage of you being able to control the variables and close proximity translates into ease in setting up an ongoing sampling schedule. A location near a window that receives direct sun only during part of the day will also offer temperature variations throughout the day. What effect does this have on the other data? The disadvantage of an in-class aquarium is the apparent artificial nature of the data, rather than being a real-life, local environment study.

The availability of a sampling source will effect how the sampling tests are used. If the source is distant and only accessible on a limited (field trip) basis, then the tests may be used as an introductory OR wrap-up activity done only once. If the source is nearby and easily accessible, the sampling could be done on an on-going basis, and a database built for the year and over the course of many years.

Saturday Afternoon
Activity 4 and Wrap-up

The following is an overview of where water testing can be used to teach some of the new standards, beginning at the 6^{th} grade level, and continuing through high school. Many of the other standards could be incorporated into lessons built around a water testing theme, depending upon the individual teacher and his/her interests. Lewis dot structures, ions, balanced equations, oxidation and reduction reactions are a few examples of some of the other standards that can be taught within the water testing theme. This activity also lends itself to a collaboration between biology and chemistry students as an integrated lesson, how applications of chemistry apply to other disciplines.

Standards:

Middle School:
Grade Six:

Ecology: Students know the number and types of organisms an ecosystem can support depends on the resources available and on abiotic factors, such as quantities of light and water, a range of temperatures, and soil composition.

Tests for pH, temperature, oxygen, phosphorus and nitrogen as limiting reagents in the support of life in the pond.

Investigation and Experimentation: Selection of the appropriate tools and technology, construct graphs from data and develop qualitative statements about the relationships between variables, communicate the steps and results from an investigation in written reports and oral presentations, identify changes in natural phenomena over time (if a series of samples is possible)

Introduce a variety of tests for the same variable, use the information to construct graphs, (i.e. temperature vs. time of day or temperature vs. month), have the students write reports in a variety of formats, such as newspaper, journal article, formal lab report or as a how-to guide. Look at the data over a long period of time and summarize any trends that occur.

Grade Eight:

Structure of Matter: know the structure of the atom, compounds are formed by combining two or more different elements, and have very different properties than the constituent elements, know how to use the periodic table to identify the elements in a compound.

These could all be introduced either before or after the sampling is done. If done after, the tests become an illustration of how scientists use this information to learn about our environment. If done before, the tests become an introduction and the follow-up lessons would be designed to give the information meaning.

Reactions: Students know reactant atoms and molecules interact to form products with different chemical properties, and know how to determine whether a solution is acidic, basic, or neutral.

Some of the chemicals used in lawn care are benign until placed in an aquatic environment, many of the common products used in general yard care react (decompose into ions) when dissolved in water, and pH is tested and the number scale introduced and explained as far as below 7 acids, 7 neutral, above 7 basic.

Investigation and Experimentation: Plan and conduct an investigation to test a hypothesis, evaluate the accuracy and reproducibility of data, distinguish between variable and controlled parameters in a test, construct graphs from data and develop quantitative statements about the relationships between variables.

Sample tests (cook-book) could be done to practice the skills needed, and then the students must develop a scheme for testing and evaluation of one or more of the parameters that describe the pond. What do the results mean? How are they useful in evaluating the health of the pond? and potential effects further along the watershed.

High School:

Direct and indirect applications of the standards include:

Chemistry:

3. The conservation of atoms in chemical reactions leads to the principle of conservation of matter and the ability to calculate the mass of products and reactants. As a basis for understanding this concept:
   a. Students know how to describe chemical reactions by writing balanced equations.
   g. Students know how to identify reactions that involve oxidation and reduction and how to balance oxidation-reduction reactions.
5. Acids, bases, and salts are three classes of compounds that form ions in water solutions.
   a. Students know the observable properties of acids a, bases and salt solutions
   d. Students know how to use the pH scale to characterize acid and base solutions.
   g. Students know buffers stabilize pH in acid-base reactions.
6. Solutions are homogeneous mixtures of two or more substances.
   a. Students know the definitions of solute and solvent.

b. Students know how to describe the dissolving process at the molecular level by using the concept of random molecular motion.
c. Students know temperature, pressure, and surface area affect the dissolving process.
d. Students know how to calculate the concentration of a solute in terms of grams per liter, molarity, parts per million, and percent composition.

9. Chemical equilibrium is a dynamic process at the molecular level. As a basis for understanding this concept:
   a. Students know how to use LeChatelier's principle to predict the effect of changes in concentration, temperature, and pressure.

Biology

Ties to biology standards for an integrated approach include:

6. Stability in an ecosystem is a balance between competing effects. As a basis for understanding this concept:
   b. Students know how to analyze changes in an ecosystem resulting from changes in climate, human activity, introduction of nonnative species, or changes in population size.
   d. Students know how water, carbon, and nitrogen cycle between abiotic resources and organic matter in the ecosystem and how oxygen cycles through photosynthesis and respiration.

Earth Sciences

7. Each element on Earth moves among reservoirs, which exist in the solid earth, in oceans, in the atmosphere, and within and among organisms as part of biogeochemical cycles. As a basis for understanding this concept:
   a. Students know the carbon cycle of photosynthesis and respiration and the nitrogen cycle.

9. The geology of California underlies the state's wealth of natural resources as well as its natural hazards.
   c. Students know the importance of water to society, the origins of California's fresh water, and the relationship between supply and demand.

Investigation and Experimentation

a. Select and use appropriate tools and technology (such as computer-linked probes, spreadsheets and graphing calculators) to perform tests, collect data, analyze relationships, and display data.
b. Identify possible reasons for inconsistent results, such as sources of error or uncontrolled conditions.
c. Formulae explanations by using logic and evidence.
k. Recognize the cumulative nature of scientific evidence.
l. Analyze situations and solve problems that require combining and applying concepts from more than one area of science.

m. Investigate a science-based societal issue by researching the literature analyzing data, and communicating the findings.